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Indian Standard

GLASS THERMOMETERS FOR PRECISION USE — SPECIFICATION

PART 2 ENCLOSED-SCALE THERMOMETERS

भारतीय मानक

कांच के लघु प्रयोग तापमापक — विशिष्टि

भाग २ संलग्न तापमापक

UDC 536·516

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

July 1989 **Price Group 4**

Laboratoryware and Related Apparatus Sectional Committee, CDC 33

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 16 January 1989, after the draft finalized by the Laboratoryware and Related Apparatus Sectional Committee had been approved by the Chemical Division Council.

To cater to the needs of the scientists in their precision scientific work on metrology, the committee responsible for preparing this standard decided to formulate Indian Standards on long and short solid-stem and enclosed-scale thermometers, intended for general use in precision work. The committee also decided to publish this standard in two parts. Part 1 covers long and short solid-stem type and Part 2 covers long and short enclosed-scale type thermometers for precision use. This standard is based on IS 8787 : 1977 'Principles of design, construction and use of liquid-in-glass thermometers'.

For ease of reference, each thermometer of this series has been allocated a designation which is a combination of letters and figures indicating the type of thermometer, the value of the smallest scale interval and the lower and upper limits of the nominal scale range. The letter abbreviations are given below:

a) STL — Long solid-stem thermometers,
b) STC — Short solid-stem thermometers,
c) EL — Long enclosed-scale thermometers, and
d) EC — Short enclosed-scale thermometers.

Part 1 covers a series of liquid-in-glass long and short solid-stem thermometers for use in precision work while Part 2 covers a series of liquid-in-glass long and short enclosed scale thermometers for use in precision work.

In the formulation of Part 1 and Part 2 of this standard, assistance has been derived from the following standards issued by the International Organization for Standardization (ISO):

ISO 653-1980	Long solid-stem thermometers for precision use
ISO 654-1980	Short solid-stem thermometers for precision use
ISO 655-1980	Long enclosed-scale thermometers for precision use
ISO 656-1980	Short enclosed-scale thermometers for precision use

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GLASS THERMOMETERS FOR PRECISION USE — SPECIFICATION

PART 2 ENCLOSED-SCALE THERMOMETERS

1 SCOPE

This standard prescribes the requirements and methods of sampling and test for a series of liquid-in-glass enclosed-scale thermometers for use in precision work.

2 REFERENCES

The Indian Standards listed below are necessary adjuncts to this standard:

IS No.	*Title*
2627 : 1979	Glossary of terms relating to liquid-in-glass thermometers (*first revision*)
4610 : 1968	Specification for glass tubes for general purpose
6274 : 1971	Methods of calibrating liquid-in-glass thermometers

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 2627 : 1979 shall apply.

4 TYPES AND GRADES

4.1 Types

The thermometers shall be of mercury-in-glass enclosed-scale type. They shall be of the following two types:

a) *Type 1* long enclosed-scale thermometer not exceeding 375 mm in length (EL); and

b) *Type 2* short enclosed-scale thermometer not exceeding 250 mm in length (EC).

4.2 Grades

The thermometers of Type 1 and Type 2 shall be of the following grades:

a) *Grade A* thermometer having no contraction chamber;

b) *Grade B* thermometer having a lower limit of the main scale above 0°C with a contraction chamber; and

c) *Grade C* (For Type 2 Only) thermometer having a lower and upper limit of the main scale below 0°C and having a contraction chamber.

5 DESIGNATION

Each thermometer of this series has been allocated a designation which is a combination of letters and figures indicating the type of thermometer, the value of the smallest scale interval and the lower and upper limits of the nominal scale range. For example, a long enclosed-scale thermometer having the value of the smallest scale interval as 0·1°C with the main scale from —25 to +5°C has been designated as EL/0·1/—25/ +5.

6 TEMPERATURE SCALE

The thermometer shall be graduated in degree celsius (°C).

7 IMMERSION

The thermometer shall be adjusted for vertical total immersion (TI) or partial immersion (PI).

NOTES

1 Partial immersion thermometers are very convenient to use when the ambient temperature in the calibrating laboratory is identical with that of the place of their use. If this condition is not obtained, these thermometers require a far more complicated correction than total immersion thermometers (*see* IS 6274 : 1971) As such, in general, the use of partial immersion thermometers shall be made with due discretion.

2 Adjustment at partial immersion is not permitted for thermometers with a scale extending below — 38°C because of the large errors likely to be caused in a spirit-in glass thermometer by variation in temperature around the emergent portion of the stem.

8 REQUIREMENTS

8.1 Materials

8.1.1 *Glass Tubing*

The thermometer shall be made of suitable thermometric glass having co-efficient of linear thermal expansion of (8·5 ± 0·3) × 10^{-6} per degree for thermometers meant for use up to 350°C and (5·0 ± 0·2) × 10^{-6} per degree for the thermometers meant for use between 350 to 500°C. The glass or glasses comprising the thermometer shall be selected and processed so that the finished thermometer shows the following characteristics:

a) Stress in the glass of the bulb and capillary stem shall be reduced to a level sufficient to minimize the possibility of fracture due to thermal or mechanical shock.

b) The bulb glass shall be stabilized by suitable heat treatment to ensure that the accuracy requirements of **8.5.2** to **8.5.4** are met.

c) The legibility of the reading shall not be impaired by devitrification or clouding.

d) The image of the meniscus shall be distorted as little as possible by defects or impurities in the glass.

8.1.2 *Thermometric Liquids*

Mercury shall be used as thermometric liquid, except for thermometers with a scale extending below −38°C for which the eutectic alloy of mercury and thallium (8·5 percent thallium by mass) shall be used. The thermometric liquids shall be free from any contamination likely to interfere with the proper functioning of the thermometer.

8.1.3 *Gas Filling*

Thermometers having an upper nominal limit above 100°C shall be filled with a dry, inert gas, preferably nitrogen, above the liquid column. The pressure of the gas shall be high enough to raise the boiling point of the thermometric liquid sufficiently to minimize vaporization.

8.2 Construction

8.2.1 *Shape*

The thermometers shall be straight and their external cross-section approximately circular.

8.2.2 *Top Finish*

The top of the thermometer shall either be finished a glass ring, or with a spherical end.

8.2.3 *Strip Bearing the Scale*

The strip bearing the scale shall be of a translucent material suitable for the temperature to be measured and compatible with the method of fixing the strip. It shall be placed tightly against the capillary tube inside the sheath and shall be firmly and securely fastened at the top of the thermometer. The fixing shall not obscure the scale. A suitable method of fixing is by fusing a glass tube or rod to the sheath and to the upper end of the strip bearing the scale while the lower end of the strip shall be freely held in a suitable saddle. Alternatively, it shall be fixed inside the sheath in any other suitable manner that also allows for differential expansion.

8.2.4 *Capillary Tube*

The thermometer shall be made from capillary tube (*see* IS 4610 : 1968) which has been so tested as to ensure that the requirements of **8.2.4.1** and **8.2.4.2** are satisfied.

8.2.4.1 The cross-sectional area of the bore shall not show variations from the average greater than 10 percent, and the bore shall be wide enough to ensure that the jumping of the meniscus does not exceed one-fifth of the graduation interval.

8.2.4.2 The capillary tube shall preferably incorporate an enamel back.

8.2.5 *Expansion Chamber* (*Safety Chamber*)

An expansion chamber shall be provided at the top of the capillary tube except for thermometers EL/1/180/420, EL/2/0/600 and EC/1/290/410. The expansion chamber, if present for those thermometers, shall be pear-shaped with the hemisphere at the top.

8.2.5.1 For thermometers EL/0·1/−25/+5, EL/0·2/−55/+5, EC/0·1/−21/−9, EC/0·1/−11/+1, EC/0·1/−1/+11, EC/0·1/9/21, EC/0·2/−38/−18, EC/0·2/−22/2, EC/0·5/−55/+2 and EC/0·2/−8/+22 the lower end of the expansion chamber shall be so elongated as to avoid the risk of a break in the mercury column during storage at ambient temperature.

8.2.5.2 The volume of expansion chamber above the scale shall be at least equivalent to that occupied by an interval of 50°C of the scale.

NOTE — Overheating is liable to change the zero point of a thermometer and a determination will be necessary if it occurs.

8.2.6 *Contraction Chamber*

Thermometers having a lower limit of the main scale above 0°C shall be provided with a contraction chamber to allow for the inclusion of an auxiliary scale (*see* Fig. 1, EL Grade B and Fig 2, EC Grade B). The contraction chamber shall be so elongated and shall be as narrow as possible to avoid the risk of a break in the mercury column at ambient temperature.

8.2.7 *Position of Chambers*

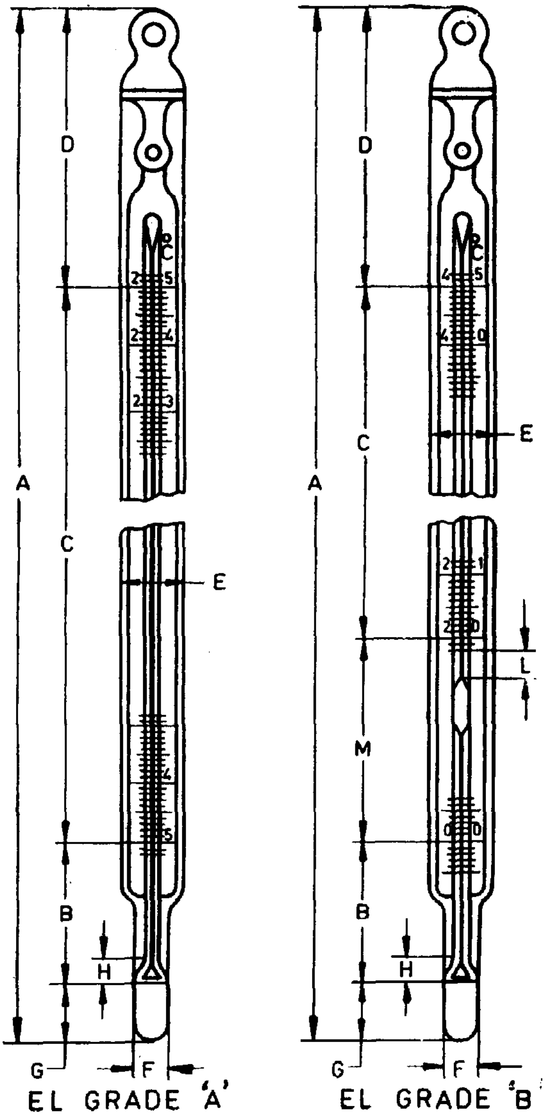
No enlargement of the bore shall be so located as to produce any variation (greater than that permitted in **8.2.4**) in the cross-section of the capillary tube in the scale portion and in all cases, there shall be at least 5 mm of unchanged capillary between any enlargement and the nearest scale line. The distance from the top of the contraction chamber to the first scale line of the scale immediately above it shall be not less than 13 mm, except that for thermometers EL/0·5/190/310, EL/1/180/420, EC/0·5/245/305, EC/1/190/310 and EC/1/290/410, this distance shall be not less than 30 mm.

8.3 Dimensions

The dimensions of the thermometers shall be as given in Table 1.

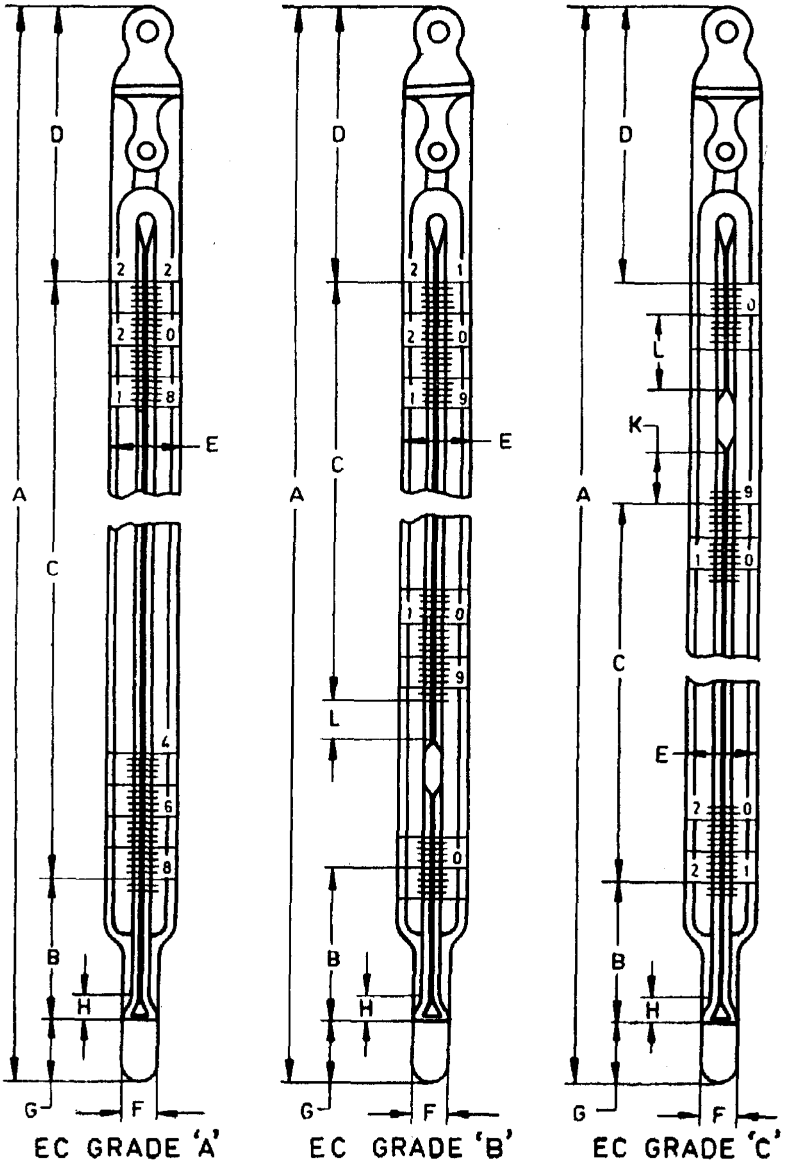
8.4 Gradation and Figuring

8.4.1 The scale ranges with scale intervals are given in Tables 2 and 3.



NOTE — The position of the top ring may be either as shown or at right angles to this.

FIG. 1 LONG ENCLOSED-SCALE THERMOMETERS FOR PRECISIONS TO THIS



NOTE — The position of the top ring may be either as shown or at right angles to this.

FIG. 2 SHORT ENCLOSED-SCALE THERMOMETERS FOR PRECISION USE

Table 1 Dimensions of Long Enclosed-Scale (Type 1) and Short Enclosed-Scale (Type 2) Thermometers for Precision Use

(*Clause* 8.3)

Sl No.	Particulars	Requirements for				
		Type 1		Type 2		
		Grade A	Grade B	Grade A	Grade B	Grade C
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Total length (*A*), mm, *Max*	375	375	250	250	250
ii)	Distance from top of bulb (shoulder) to lower nominal limit of scale (*B*), mm, *Min*	35	—	30	—	30
iii)	Distance from top of bulb (shoulder) to 0°C scale line (*B*), mm, *Min*	—	35	—	30	—
iv)	Length of main scale (nominal limits) (*C*), mm, *Min*	220	170	120	80	80
v)	Distance from upper nominal limit of scale to top of thermometer (*D*), mm, *Min*	50	50	50	50	—
vi)	Distance from 0°C graduation line to top of thermometer (*D*), mm, *Min*	—	—	—	—	50
vii)	Diameter of sheath (*E*), mm	9·0 ± 1·0	9·0 ± 1·0	9·0 ± 1·0	9·0 ± 1·0	9·0 ± 1·0
viii)	External diameter of bulb (*F*), mm	6·0 ± 0·5	6·0 ± 0·5	5·0 ± 0·5	5·0 ± 0·5	5·0 ± 0·5
ix)	Length of bulb to shoulder (*G*), mm, *Min*	15	15	15	15	15
x)	Distance from shoulder of bulb to lower end of parallel sided capillary tube (*H*), mm, *Max*	5	5	5	5	5
xi)	Distance from bottom of contraction chamber to highest scale line on scale below it (*K*), mm, *Min*	—	—	—	—	5
xii)	Distance from top of contraction chamber to lowest scale line on scale above it (*L*), mm, *Min*	—	13*	—	13†	13
xiii)	Distance from zero below the contraction chamber to lowest scale line on scale above it (*M*), mm, *Min*	—	50	—	—	—

*Except for thermometers EL/0·5/190/310 and EL/1/180/420 for which this distance shall be at least 30 mm.

†Except for thermometers EC/0·5/245/345, EC/1/190/310 and EC/1/290/410 for which this dimension shall be at least 30 mm.

Table 2 Graduation of Long Enclosed-Scale Thermometers for Precision Use

(*Clause* 8.4.1)

Sl No.	Designation	Inscription	Scale Interval °C	Main Scale °C	Auxiliary Scale °C	Grade
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	EL/0·1/ — 25/ + 5	EL 1	0·1	— 25 to + 5	—	A
2.	EL/0·1/ — 5/ + 25	EL 2	0·1	— 5 to + 25	—	A
3.	EL/0·1/20/45	EL 3	0·1	20 to 45	– 0·5 to +0·5	B
4.	EL/0·1/40/65	EL 4	0·1	40 to 65	– 0·5 to +0·5	B
5.	EL/0·1/60/85	EL 5	0·1	60 to 85	—0·5 to +0·5	B
6.	EL/0·1/80/105	EL 6	0·1	80 to 105	—0·5 to +0·5	B
7.	EL/0·2/ — 55/ + 5	EL 7	0·2	— 55 to +5	—	A
8.	EL/0·2/ — 35/ + 25	EL 8	0·2	— 35 to +25	—	A
9.	EL/0·2/ — 15/ + 45	EL 9	0·2	— 15 to +45	—	A
10.	EL/0·2/35/85	EL 10	0·2	35 to 85	—1 to +1	B
11.	EL/0·2/75/125	EL 11	0·2	75 to 125	—1 to +1	B
12.	EL/0·2/115/165	EL 12	0·2	115 to 165	—1 to +1	B
13.	EL/0·2/155/205	EL 13	0·2	155 to 205	—1 to +1	B
14.	EL/0·5/ — 35/ + 115	EL 14	0·5	— 35 to +115	—	A
15.	EL/0.5/90/210	EL 15	0·5	90 to 210	—3 to +3	B
16.	EL/0·5/190/310	EL 16	0.5	190 to 310	—3 to +3	B
17.	EL/1/ — 30/ + 270	EL 17	1	— 30 to +270	—	A
18.	EL/1/180/420	EL 18	1	180 to 420	—5 to +5	B
19.	EL/2/0/600	EL 19	2	0 to 600	—	A

Table 3 Graduation of Short Enclosed-Scale Thermometers for Precision Use

(*Clause* 8.4.1)

Sl No.	Designation	Inscription	Scale Interval °C	Main Scale °C	Auxiliary Scale °C	Grade
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	EC/0·1/ —2/ – 9	EC 1	0·1	—21 to – 9	—0·5 to +0·5	C
2.	EC/0·1/ —11/ +1	EC 2	0·1	—11 to +1	—	A
3.	EC/0·1/ —1/ +11	EC 3	0·1	—1 to +11	—	A
4.	EC/0·1/9/21	EC 4	0·1	9 to 21	—0·5 to +0·5	B
5.	EC/0·1/19/31	EC 5	0·1	19 to 31	—0·5 to +0·5	B
6.	EC/0·1/29/41	EC 6	0·1	29 to 41	—0·5 to +0·5	B
7.	EC/0·1/39/51	EC 7	0·1	39 to 51	—0·5 to +0·5	B
8.	EC/0·1/49/61	EC 8	0·1	49 to 61	—0·5 to +0·5	B
9.	EC/0·1/59/71	EC 9	0·1	59 to 71	—0·5 to +0·5	B
10.	EC/0·1/69/81	EC 10	0·1	69 to 81	—0·5 to +0·5	B
11.	EC/0·1/79/91	EC 11	0·1	79 to 91	—0·5 to +0·5	B
12.	EC/0·1/89/101	EC 12	0·1	89 to 101	—0·5 to +0·5	B
13.	EC/0·2/ —38/ —18	EC 13	0·2	—38 to —18	—1 to +1	C
14.	EC/0·2/ – 22/ +2	EC 14	0·2	—22 to +2	—	A
15.	EC/0·2/ —8/ +22	EC 15	0·2	—8 to +22	—	A
16.	EC/0·2/18/42	EC 16	0·2	18 to 42	—1 to +1	B
17.	EC/0·2/38/62	EC 17	0·2	38 to 62	—1 to +1	B
18.	EC/0·2/58/82	EC 18	0·2	58 to 82	—1 to +1	B
19.	EC/0·2/78/102	EC 19	0·2	78 to 102	—1 to +1	B
20.	EC/0·2/98/122	EC 20	0·2	98 to 122	—1 to +1	B
21.	EC/0·2/118/142	EC 21	0·2	118 to 142	—1 to +1	B
22.	EC/0·2/138/162	EC 22	0·2	138 to 162	—1 to +1	B
23.	EC/0·2/158/182	EC 23	0·2	158 to 182	—1 to +1	B
24.	EC/0·2/178/202	EC 24	0·2	178 to 202	—1 to +1	B
25.	EC/0·5/ — 55/ + 2	EC 25	0·5	— 55 to + 2	—	A
26.	EC/0·5/ — 38/ + 35	EC 26	0·5	— 38 to + 35	—	A
27.	EC/0·5/ — 5/ + 70	EC 27	0·5	— 5 to + 70	—	A
28.	EC/0·5/45/105	EC 28	0·5	45 to 105	– 3 to +3	B
29.	EC/0·5/95/155	EC 29	0·5	95 to 155	—3 to +3	B
30.	EC/0·5/145/205	EC 30	0·5	145 to 205	—3 to +3	B
31.	EC/0·5/195/255	EC 31	0·5	195 to 255	—3 to +3	B
32.	EC/0·5/245/305	EC 32	0·5	245 to 305	—3 to +3	B
33.	EC/1/ — 30/ + 120	EC 33	1	— 30 to + 120	—	A
34.	EC/1/90/210	EC 34	1	90 to 210	—5 to +5	B
35.	EC/1/190/310	EC 35	1	190 to 310	—5 to +5	B
36.	EC/1/290/410	EC 36	1	290 to 410	—5 to +5	B

8.4.2 The scale lines shall be clearly and permanently marked on the strip and shall be of uniform thickness which shall not exceed 0·15 mm. The lines shall be at right angles to the axis of the thermometer.

8.4.3 When the thermometer is held in a vertical position and viewed from the front, the left-hand ends of all the scale lines shall lie on an imaginary vertical line. When the thermometer is viewed so that the right-hand ends of the shortest scale lines align with the left-hand side of the bore, the medium and longer lines referred to shall extend towards the right-hand side of the bore.

8.4.4 The length of the short scale lines shall be approximately 1 mm. The medium scale lines shall be nominally 1·5 times the length of the short scale lines, and the long scale lines shall be nominally 2·5 times the length of the short scale lines.

8.4.5 The arrangement of the scale lines shall be as follows.

8.4.5.1 On thermometers where the smallest scale division is 1°C or 0·1°C:

a) Every tenth scale line shall be a long line,

b) There shall be a medium line midway between two consecutive long lines, and

c) There shall be four short lines between consecutive medium and long lines (*see* *A* and *D* of Fig. 3).

8.4.5.2 On thermometers where the smallest scale division is 2°C or 0 2°C:

a) Every fifth scale line shall be a long line, and

b) There shall be four short lines equally spaced between two consecutive long lines (*see* *B* and *E* of Fig. 3).

8.4.5.3 On thermometers where the smallest scale division is 0·5°C:

a) Every tenth scale line shall be a long line,

b) There shall be four medium lines equally spaced between two consecutive long lines, and

c) There shall be one short line between two consecutive medium lines or between consecutive medium and long lines (*see* *C* of Fig. 3).

8.4.6 The figures shall be placed either slightly to the left or the right of the line to which they refer, as preferred, in such a way that an extension of the line would bisect them or pass immediately under them. The figures may be placed either parallel to, or at right angles to, the axis of the thermometer, as preferred.

NOTE — Fig. 3 illustrates various types of graduation and figuring for the thermometers, but these are not intended to be mandatory.

8.4.7 Every tenth scale line shall be figured. Thus, in the case of a smallest scale division of:

a) 0·1°C, the series of figures shall be: 1 — 2 — 3 — etc.

b) 1°C, the series of figures shall be: 10 — 20 — 30 — etc.

c) 0·2°C the series of figures shall be: 2 — 4 — 6 — etc.

d) 2°C, the series of figures shall be: 20 — 40 — 60 — etc.

e) 0·5°C, the series of figures shall be: 5 — 10 — 15 — etc.

The auxiliary scale shall be figured at 0°C. Scale lines at 0, 10 or 100°C should be emphasised (for example, by full figuring if either the first, or the first and the second digits are omitted at intermediate scale lines).

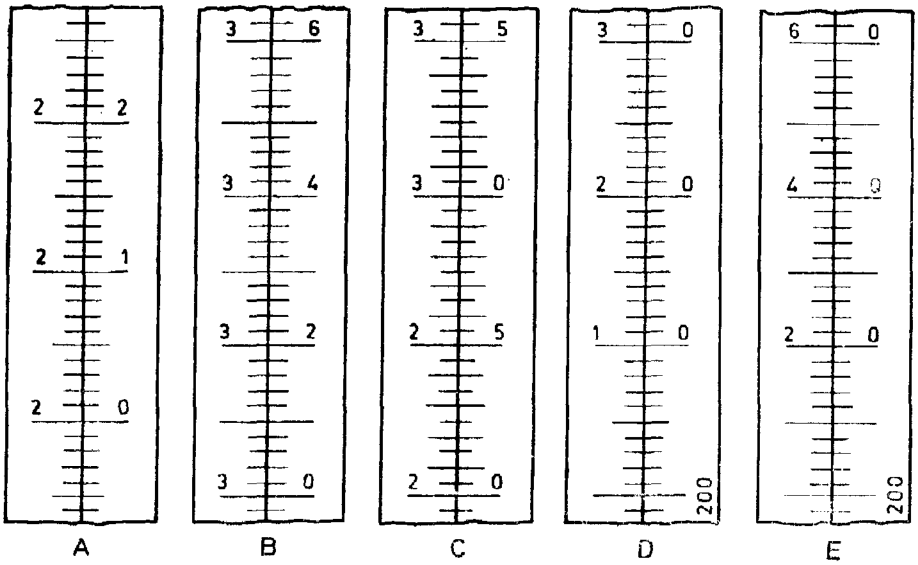


Fig. 3 Alternative Types of Graduation and Figuring

8.4.8 The pigment filling shall remain in the scale lines, figures and inscriptions under normal conditions of the use and under such other special conditions as may be specified between the purchaser and the manufacturer.

8.4.9 Each end of the scale shall be extended by two to five divisions beyond the nominal limits of the scale.

8.4.10 All negative numbers should be indicated by minus signs, for example, —5 or 5 as preferred, and shall be so placed that they are not liable to be confused with the scale lines, or other markings.

8.5 Accuracy

8.5.1 The accuracy tests shall be carried out in accordance with IS 6274 : 1971.

8.5.2 *Scale Error*

The maximum permissible scale error shall not be more than one scale division when the thermometer is in a vertical position and at the prevailing atmospheric pressure under the conditions of immersion after applying emergent stem correction.

8.5.3 *Interval Error*

The absolute value of the algebraic difference between the errors at any two points which are not more than 50 divisions apart, shall not be greater than one scale division.

8.5.4 *Change in Zero*

When a thermometer having an upper nominal limit above 100°C is maintained over a period of 24 hours at the highest temperature of the scale, the change in the zero point, determined by the method prescribed in Annex A, shall not exceed 0·7 of a scale division, and the scale error shall remain within the limit of one scale division specified in **8.5.2.**

9 MARKING AND PACKING

9.1 Marking

Each thermometer shall be legibly and permanently marked on its stem with the following:

a) The letter 'C' near the top of the scale;
b) The maker's name or his recognized mark, if any;
c) Serial number of the thermometer;
d) The year of manufacture;
e) Schedule mark followed by TI or PI as the case may be;
f) Immersion line on partial immersion thermometers with an indication of its depth of immersion for which the thermometer has been adjusted;
g) Designation number (*see* **5**); and
h) Gas filled, if any, for example, 'NF' for nitrogen filled.

9.1.1 The thermometers may also be marked with the Standard Mark.

9.2 Packing

Each thermometer shall be suitably packed as agreed to between the purchaser and the manufacturer.

10 TESTING AND INSPECTION

10.1 Each thermometer shall be tested for conformity to all the requirements of this specification.

ANNEX A

(*Clause* 8.5.4)

METHOD OF DETERMINING CHANGE IN ZERO INDICATION

A-1 PROCEDURE

Heat the thermometer, immersed in a bath, to a temperature equal to its highest reading and keep it at this temperature for 5 minutes. Allow the thermometer to cool either naturally in still air or slowly in the test bath (at a reproducible rate) to 20°C above ambient temperature or to 50°C, whichever is lower, and then determine the zero. If natural cooling is used, the zero should be determined within 1 hour. Heat the thermometer again to a temperature equal to it highest reading and keep it at this temperature for 24 hours. Allow the thermometer to cool to the lower of two temperatures referred to above, at the same rate as at the start for cooling during the test and observe the change in zero under the same conditions.

NOTE — This test is appropriate to thermometers having an upper nominal limit above 100°C.

Standard Mark

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

Bureau of Indian Standards

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